

REMARKS

Claims 1-12 are pending in the present application. Reconsideration of the claims is respectfully requested.

Applicants wish to thank the Examiner for his courtesy in holding a telephonic interview on February 20, 2003. During the interview, the following points were discussed.

1. 35 U.S.C. § 102, Anticipation

The Examiner has rejected claims 1-5, 11 and 12 under 35 U.S.C. § 102(b) as being anticipated by Patent No. 6,137,497 to *Strunk et al.* This rejection is respectfully traversed.

With respect to claim 1, which is representative of the other rejected claims, the Office Action states:

(a) Regarding claim 1, *Strunk et al.* discloses a method in a graphics adapter for displaying an object, the method comprising: receiving position coordinates ("eye" coordinates 110 (eye space)) and texture coordinates ("object" coordinates 108 (object space)) for the object; inverting a depth coordinate (modelview matrix (M^{-T}) associated with the position and the texture coordinates to form an inverted coordinate (concatenated PVD matrix (PDV) $^{-T}$); multiplying the position coordinates and the texture coordinates by the inverted coordinate to form adjusted position coordinates and adjusted texture coordinates (homogeneous window coordinates...col. 5, lines 38-40) (...model clipping planes are transformed from eye coordinates—to homogeneous window coordinates...by multiplying model clipping plane coefficients by the inverted...PVD matrix...col. 5, lines 35-38); and displaying the object using the adjusted position coordinates and the adjusted texture coordinates (homogeneous window coordinates...col. 5, lines 38-40).

A prior art reference anticipates the claimed invention under 35 U.S.C. § 102 only if every element of a claimed invention is identically shown in that single reference, arranged as they are in the claims. *In re Bond*, 910 F.2d 831, 832, 15 U.S.P.Q.2d 1566, 1567 (Fed. Cir. 1990). *Strunk* fails to anticipate the presently claimed invention because it fails to show all of the elements of the claimed invention.

The rejected independent claims, 1, 2, 11, and 12, all recite in some form the features of inverting a depth coordinate to obtain an inverted depth coordinate and multiplying position and/or texture coordinates by the inverted depth coordinate. These features are not taught by *Strunk*.

A. The cited portions of Strunk fail to teach all of the elements of the rejected claims

The Examiner argues that the matrix M^{-T} is a depth coordinate and that *Strunk* teaches inverting matrix M^T to obtain a matrix $(PVD)^{-T}$. Applicants disagree for a number of reasons. First, neither matrix M^T nor matrix $(PVD)^{-T}$ are coordinates, much less depth coordinates. Second, *Strunk* never teaches inverting matrix M^T . Third, even if matrix M^T is inverted, the result would not be matrix $(PVD)^{-T}$. Each of these points is explained below.

The matrices M^{-T} and $(PVD)^{-T}$ are not depth coordinates or inverted depth coordinates, because they are not coordinates. Matrices M^T and $(PVD)^{-T}$ are actually transformation matrices, not coordinates. Matrices M^T and $(PVD)^{-T}$ transform a first set of coordinates into a second set of coordinates by multiplying the first set of coordinates by one of the transformation matrices (M^T or $(PVD)^{-T}$). As the following excerpt regarding matrix $(PVD)^{-T}$ states:

According to another aspect of the present invention, model clipping planes are transformed from eye coordinates to homogeneous window coordinates by multiplying model clipping plane coefficients by the inverted and transposed concatenated PVD matrix $((PVD)^{-T})$. [col. 5, lines 34-38].

A transformation matrix of this kind is different from a coordinate, because a transformation matrix is a matrix, while a coordinate is a scalar value. Moreover, transformation matrices are *square* matrices, so that not only are not individual coordinates, they are also distinct from a vector of coordinates. Transformation matrices M^T and $(PVD)^{-T}$ are, by definition, square matrices (and, hence, not a vector or a scalar), because only square matrices can be inverted and M^T and $(PVD)^{-T}$ are themselves the inverse matrices of M^T and $(PVD)^T$, respectively. Thus, matrices M^{-T} and $(PVD)^{-T}$ are neither coordinates nor vectors of coordinates. Hence, neither matrix M^{-T} nor matrix $(PVD)^{-T}$ is a depth coordinate or an inverted coordinate, as recited in the claims.

Strunk does not teach inverting matrix M^{-T} , as the Examiner argues. The inverse of matrix M^{-T} would be M^T , the transpose of matrix M . *Strunk* does not teach inverting matrix M^{-T} to obtain M^T . Moreover, *Strunk* contains no teaching or suggestion that the inverse of M^{-T} , namely M^T , is equal to matrix $(PVD)^{-T}$, as the Examiner contends.

Actually, *Strunk* teaches that the matrices M , P , V , and D , from which matrices M^{-T} and $(PVD)^{-T}$ are derived, are distinct matrices, which would suggest that inverting M^{-T} would not result in $(PVD)^{-T}$:

According to an aspect of the present invention, vertex data defining graphics primitives is transformed to homogeneous window coordinates where view clipping and model clipping are performed. Thus, each vertex of a graphics primitive is multiplied by a concatenation of the current modelview (M), projection (P), Viewport (V), and device (D) matrices (i.e., a MPVD matrix) to transform the vertex data into homogeneous window coordinates, regardless of whether the vertex may be clipped away by a clipping plane. [col. 5, lines 19-28].

Thus, Applicants respectfully submit that the basis for the Examiner's argument, that matrices M^{-T} and $(PVD)^{-T}$ correspond to a depth coordinate and inverted coordinate, respectively, is inaccurate. The argument that *Strunk* teaches the recited multiplication feature also fails for the same reasons. The Examiner cites to col. 5, lines 35-40 as teaching this multiplication feature:

The model clipped vertex data is then transformed from eye coordinates 110 to clip coordinates 112 where view clipping is performed, by multiplying the model clipped vertex data by the current projection matrix (P) 102. After performing view clipping, the view and model clipped vertex data is transformed to "window" coordinates 116 (window space) by performing perspective division 104 and multiplying the view and model clipped vertex data by the current viewport (V) and device (D) matrices 106. [col. 5, lines 33-41].

The above excerpt teaches the use of transformation matrices to transform a first set of coordinates into a second set of coordinates through matrix multiplication. The transformation matrices described in the above excerpt are not coordinates or inverse coordinates, because they are, by definition, square matrices. Thus, the above excerpt fails to teach the claimed features of inverting a depth coordinate to obtain an inverted depth coordinate and multiplying position and/or texture coordinates by the inverted depth coordinate.

B. The portions not relied upon by the Examiner also fail to teach the claimed invention

Additionally, when *Strunk* is considered in its entirety, it is clear to one skilled in the art that the claimed features of inverting a depth coordinate to obtain an inverted depth coordinate and multiplying position and/or texture coordinates by the inverted depth coordinate are not taught or suggested by *Strunk* at all. *Strunk* teaches a method of performing graphics clipping using homogeneous window coordinates:

According to an aspect of the present invention, vertex data defining graphics primitives is transformed to homogeneous window coordinates where view clipping and model clipping are performed. [col. 5, lines 19-22].

Strunk defines homogeneous window coordinates as position or texture coordinates on which perspective division has not been performed:

It should be noted that the term "homogeneous window coordinates" is used here to distinguish from window coordinates 116 described with respect to FIG. 1. In particular, the term "homogeneous" is used to emphasize that perspective division 104 has not yet occurred. [col. 11, lines 42-46].

While *Strunk* does not define perspective division, perspective division, as it is known in the art, means the adjustment of coordinates to take into account the rules of perspective (in which far-away objects appear smaller) by dividing the coordinates by an additional depth coordinate (usually denoted as "W"). Thus, *Strunk* states that the homogeneous coordinates used throughout *Strunk* contain *four* values, the usual X, Y, and Z coordinates of three-dimensional space and the W depth coordinate. Perspective division would eliminate the fourth "W" coordinate, because perspective division replaces the homogeneous (X,Y,Z,W) coordinates with adjusted coordinates (X/W, Y/W, Z/W) obtained by dividing the other three coordinates by the depth coordinate "W."

Consider the following excerpt from *Strunk*:

The primitive data received by driver 404 is defined in terms of homogeneous coordinates. That is, all coordinates and spaces contain 4 values, one for each of X, Y, Z, and W. Similarly, the processed primitive data provided by driver 404 to the front-end subsystem 402 is also defined in terms of homogeneous coordinates and spaces. [col. 10, lines 35-39].

The present invention is different. The present invention is directed toward a novel method and apparatus for performing perspective division:

Perspective divide unit 424 is used to transform clip coordinates to normalize device coordinates $[-1, +1]$ by dividing a fourth coordinate W . The mechanism of the present invention is implemented within perspective divide unit 424 in these examples. The mechanism of the present invention provides for correction of both pixel coordinates (X , Y , and Z) and texture coordinates (S , T , R , and Q) using W . [p. 13, lines 10-17].

Unlike prior art approaches to perspective division, the present invention accomplishes perspective division using two operations, inversion of the depth coordinate and multiplication:

Further, the mechanism of the present invention adjusts these coordinates using multiplication, rather than division. Instead of dividing the coordinates by the depth value W , a reciprocal of the depth value W is generated. This reciprocal, $1/W$ is multiplied with the pixel coordinates and texture coordinates. [p. 13, lines 23-28].

Thus, the title of the present application refers to this operation as "perspective correction," rather than the more commonly-used term "perspective division," which suggests that division, rather than multiplication, is used.

A preferred hardware embodiment of Applicants' invention exploits this substitution of the two operations of inversion and multiplication for division by allowing perspective correction to be performed in only five clock cycles:

In addition, the mechanism of the present invention uses two stages. In the first stage the reciprocal of the depth value W occurs. A first FIFO in this stage is used to hold the pixel coordinates and the texture coordinates until the reciprocal of the depth value is generated. When the second stage receives the reciprocal of W and the pixel coordinates and the texture coordinates, multiplication of the pixel coordinates and the texture coordinates occurs. The mechanism of the present invention allows for multiplication of all of these coordinates in the same amount of time, which is five clock cycles in this example. [p. 13, line 28 -- p. 14, line 9].

Thus, the claimed features of inverting a depth coordinate to obtain an inverted depth coordinate and multiplying position and/or texture coordinates by the inverted depth coordinate are not only not taught or suggested by *Strunk*, but *Strunk* actually avoids the issue of perspective correction altogether, by teaching a method of applying

graphics clipping to homogeneous coordinates on which no perspective correction has been performed. Although Applicants acknowledge *Strunk* mentions perspective division in passing (e.g., col. 3, lines 36-41 and col. 4, lines 16-21), *Strunk* does not teach how perspective division can or should be carried out.

For the foregoing reasons, Applicants respectfully submit that *Strunk* does not teach or suggest all of the limitations of the present invention as recited in independent claims 1, 2, 11, and 12. Applicants maintain that these claims are patentable over *Strunk* and are in condition for allowance.

Claims 3-5 are dependent claims that depend on independent claims 1, 2, 11, and 12. Applicants have already demonstrated claims 1, 2, 11, and 12 to be in condition for allowance. Applicants respectfully submit that claims 3-5 are also allowable, at least by virtue of their dependency on allowable claims. Accordingly, Applicants respectfully request that claims 1-5 and 11-12 be allowed.

Furthermore, *Strunk* does not teach, suggest, or give any incentive to make the needed changes to reach the presently claimed invention. Because *Strunk* is directed toward a method of performing clipping on homogeneous window coordinates in which perspective correction has not been performed, *Strunk* does not address the problem of efficient perspective correction. *Strunk* mentions "perspective division" in passing, as a typical stage in three-dimensional graphics processing (col. 3, lines 36-41; col. 4, lines 16-21), but does not teach how "perspective division" is or should be performed.

To the extent that perspective correction is addressed, however, *Strunk* arguably suggests that the conventional prior art technique of using division to perform perspective correction should be employed, rather than using inversion and multiplication, since at the portions of *Strunk* in which perspective correction is mentioned in passing, the term "perspective division" is used. That would seem to suggest that, at least to the limited extent the inventors of *Strunk* considered the need for perspective correction, the inventors of *Strunk* had division, rather than inversion and multiplication, in mind. It follows, then, that at least to the extent *Strunk* uses the term "perspective division" to means perspective correction, the *Strunk* reference teaches away from the presently claimed invention.

Thus, absent some additional teaching or incentive from the prior art to modify *Strunk* to perform perspective correction by inversion and multiplication, rather than through the division, one of ordinary skill in the art would not be led to modify *Strunk* to reach the present invention when the reference is examined as a whole. Thus, the presently claimed invention can be achieved from the teachings of *Strunk* only through an improper use of hindsight using Applicants' disclosure as a template to make the necessary changes to reach the claimed invention.

II. 35 U.S.C. § 103, Obviousness, Claim 6

The Examiner has rejected claim 6 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,137,497 to *Strunk* et al. in view of U.S. Patent No. 5,862,356 to *Normoyle* et al. This rejection is respectfully traversed.

Claim 6 is a dependent claim that depends from independent claim 2 and is patentable for at least the same reasons as claim 2, by virtue of its dependency on claim 2. Further, the Examiner's proposed combination of *Strunk* and *Normoyle* would not be obvious to one of ordinary skill in the art, since *Normoyle* is directed toward the entirely unrelated problem of bus arbitration. *Normoyle*'s suggestion to minimize clock cycles as a goal within the context of bus arbitration is meaningless when taken out of that context, and would not prompt one of ordinary skill in the art to modify *Strunk* in such a way as to achieve the present invention. Thus, Applicants respectfully request that claim 6 be allowed.

III. 35 U.S.C. § 103, Obviousness, Claims 7-10

The Examiner has rejected claims 7-10 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,137,497 to *Strunk* et al. in view of U.S. Patent No. 5,805,868 to *Murphy*. This rejection is respectfully traversed.

Independent claim 7 recites inverting a depth coordinate and multiplying position coordinates by the inverted depth coordinate. As explained in Section I of this Response, *Strunk* neither teaches nor suggests these features. Applicants further submit that the *Murphy* reference cited by the Examiner with respect to claims 7-10 fails to cure the deficiencies of *Strunk* with respect to these claimed features.

Murphy is directed toward a graphics subsystem with a "fast clear" capability for rapidly clearing the contents of a graphics-related memory space. *Murphy* is not directed toward the problem of perspective correction, nor does *Murphy* teach or suggest features for doing so, as are recited in independent claim 7. Thus, the cited *Strunk* and *Murphy* references neither teach nor suggest all elements of claim 7, and one of ordinary skill in the art would not be motivated from the prior art to modify and combine the references' teachings to achieve the present invention.

As claims 8-10 are dependent claims incorporating the subject matter of claim 7, claims 8-10 are also allowable at least by virtue of their dependency on claim 7. Applicants therefore respectfully request that claims 7-10 be allowed.

IV. Conclusion

It is respectfully urged that the subject application is patentable over the cited references and is now in condition for allowance.

The Examiner is invited to call the undersigned at the below-listed telephone number if in the opinion of the Examiner such a telephone conference would expedite or aid the prosecution and examination of this application.

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Respectfully submitted,

Michael R. Nichols

Michael R. Nichols
Reg. No. 46,959
Carstens, Yee & Cahoon, LLP
P.O. Box 802334
Dallas, TX 75380
(972) 367-2001
Attorney for Applicant